



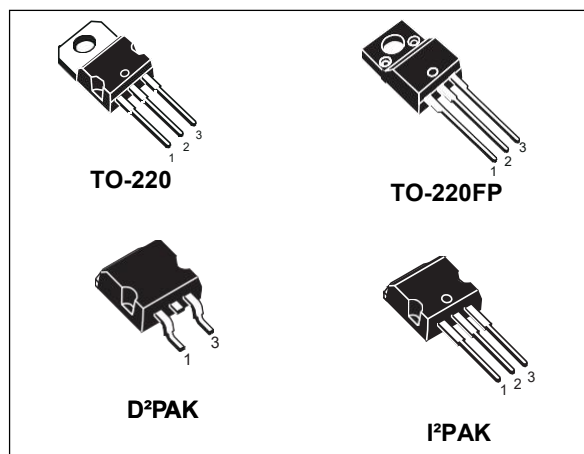
STB11NM60FD - STB11NM60FD-1 STP11NM60FD - STP11NM60FD FP

N-channel 600V - 0.40 Ω - 11A - TO-220/TO-220FP/D²PAK/I²PAK
FDmesh™ Power MOSFET (with fast diode)

General features

Type	V _{DSS}	R _{DS(on)}	I _D
STB11NM60FD	600V	<0.45 Ω	11A
STB11NM60FD-1	600V	<0.45 Ω	11A
STP11NM60FD	600V	<0.45 Ω	11A
STP11NM60FD FP	600V	<0.45 Ω	11A

- 100% avalanche tested
- High dv/dt and avalanche capabilities
- Low input capacitance and gate charge
- Low gate input resistance
- Tight process control and high manufacturing yields



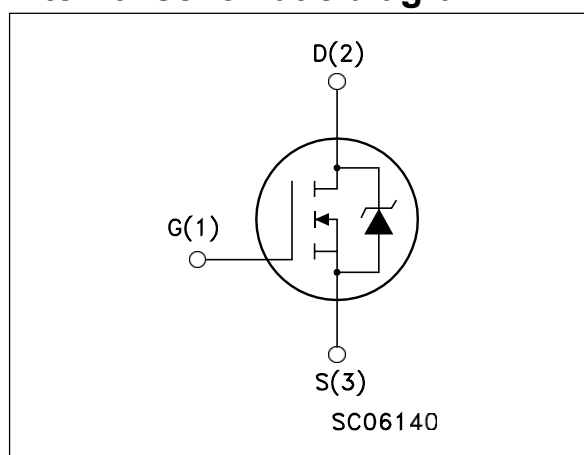
Description

The FDmesh™ associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

Applications

- Switching application

Internal schematic diagram



Order codes

Part number	Marking	Package	Packaging
STB11NM60FD	B11NM60FD	D ² PAK	Tape & reel
STB11NM60FD-1	B11NM60FD	I ² PAK	Tube
STP11NM60FD	P11NM60FD	TO-220	Tube
STP11NM60FD FP	P11NM60FD FP	TO-220FP	Tube

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1 Electrical ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value		Unit
		TO-220/ D ² PAK/I ² PAK	TO-220FP	
V _{DS}	Drain-source voltage (v _{gs} = 0)	600		V
V _{DGR}	Drain-gate voltage (R _{GS} = 20 k Ω)	600		V
V _{GS}	Gate- source voltage	± 30		V
I _D	Drain current (continuous) at T _C = 25°C	11	11 ⁽¹⁾	A
I _D	Drain current (continuous) at T _C = 100°C	7	7 ⁽¹⁾	A
I _{DM} ⁽²⁾	Drain current (pulsed)	44	44 ⁽¹⁾	A
P _{TOT}	Total dissipation at T _C = 25°C	160	35	W
	Derating factor	0.88	0.28	W/°C
dv/dt ⁽³⁾	Peak diode recovery voltage slope	20		V/ns
V _{ISO}	Insulation withstand voltage (dc)	--	2500	V
T _{stg}	Storage temperature	-65 to 150		°C

1. Limited only by maximum temperature allowed

2. Pulse width limited by safe operating area

3. I_{SD} < 11A, di/dt < 400A/ μ s, V_{DD} = 80% V_{(BR)DSS}

Table 2. Thermal resistance

Symbol	Parameter	Value		Unit
		TO-220 D ² PAK/I ² PAK	TO-220FP	
R _{thj-case}	Thermal resistance junction-case Max	0.78	3.57	°C/W
R _{thj-a}	Thermal resistance junction-ambient Max	62.5		°C/W
T _I	Maximum lead temperature for soldering purpose	300		°C

Table 3. Avalanche data

Symbol	Parameter	Value	Unit
I _{AR}	Avalanche current, repetitive or not-repetitive (pulse width limited by T _J max)	5.5	A
E _{AS}	Single pulse avalanche energy (starting T _J = 25°C, I _D = I _{AR} , V _{DD} = 35V)	350	mJ

2 Electrical characteristics

($T_{CASE}=25^{\circ}\text{C}$ unless otherwise specified)

Table 4. On/off states

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 250\text{ }\mu\text{A}$, $V_{GS} = 0$	600			V
I_{DSS}	Zero gate voltage Drain current ($V_{GS} = 0$)	$V_{DS} = \text{Max rating}$ $V_{DS} = \text{Max rating}$, $T_C = 125^{\circ}\text{C}$			1 100	μA μA
I_{GSS}	Gate-body leakage current ($V_{DS} = 0$)	$V_{GS} = \pm 30\text{V}$			± 100	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$, $I_D = 250\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10\text{V}$, $I_D = 5.5\text{A}$		0.40	0.45	W

Table 5. Dynamic

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$, $I_D = 5.5\text{A}$		5.2		S
C_{iss}	Input capacitance	$V_{DS} = 25\text{V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$		900		pF
C_{oss}	Output capacitance			350		pF
C_{rss}	Reverse transfer capacitance			35		pF
$C_{oss\text{ eq}}^{(2)}$	Equivalent output capacitance	$V_{GS} = 0\text{V}$, $V_{DS} = 0\text{V}$ to 400V		100		pF
R_G	Gate input resistance	$f = 1\text{ MHz}$ Gate DC Bias = 0 test signal level = 20mV open drain		3		Λ
Q_g	Total gate charge	$V_{DD} = 400\text{V}$, $I_D = 11\text{A}$, $V_{GS} = 10\text{V}$ (see Figure 15)		28	40	nC
Q_{gs}	Gate-source charge			7.8		nC
Q_{gd}	Gate-drain charge			13		nC

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5 %
2. $C_{oss\text{ eq}}$ is defined as a constant equivalent capacitance giving the same charging time as C_{oss} when V_{DS} increases from 0 to 80% V_{DSS} .

Table 6. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 250V$, $I_D = 5.5A$ $R_G = 4.7\Omega$, $V_{GS} = 10V$ (see Figure 14)		20		ns
t_r	Rise time			16		ns
$t_{r(Voff)}$	Off-voltage rise time	$V_{DD} = 400V$, $I_D = 11A$, $R_G = 4.7\Omega$, $V_{GS} = 10V$ (see Figure 16)		10		ns
t_f	Fall time			15		ns
t_c	Cross-over time			24		ns

Table 7. Source drain diode

Symbol	Parameter	Test conditions	Min	Typ.	Max	Unit
I_{SD}	Source-drain current				11	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)				44	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 11A$, $V_{GS} = 0$			1.5	V
t_{rr}	Reverse recovery time	$I_{SD} = 11A$, $V_{DD} = 50V$ $di/dt = 100A/\mu s$, (see Figure 19)		140		ns
Q_{rr}	Reverse recovery charge			680		nC
I_{RRM}	Reverse recovery current			A		A
t_{rr}	Reverse recovery time	$I_{SD} = 11A$, $V_{DD} = 50V$ $di/dt = 100A/\mu s$, $T_J = 150^\circ C$ (see Figure 19)		260		ns
Q_{rr}	Reverse recovery charge			1600		nC
I_{RRM}	Reverse recovery current			13		A

1. Pulse width limited by safe operating area.

2. Pulsed: Pulse duration = 300 μs , duty cycle 1.5 %

2.1 Electrical characteristics (curves)

Figure 1. Safe operating area

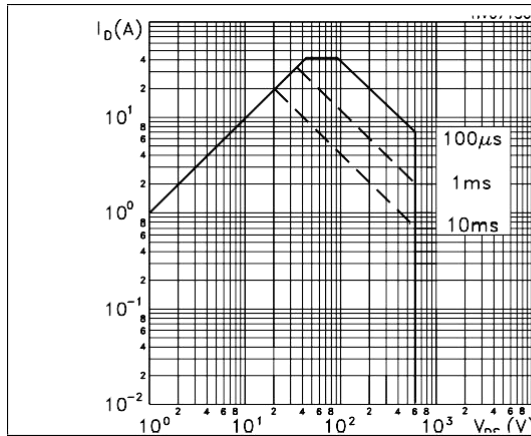


Figure 2. Thermal impedance

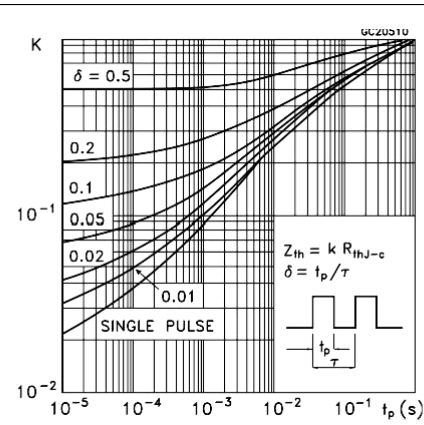


Figure 3. Safe operating area for TO-220FP

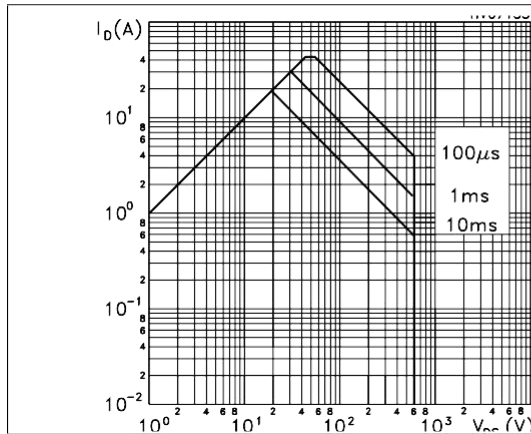


Figure 4. Thermal impedance for TO-220FP

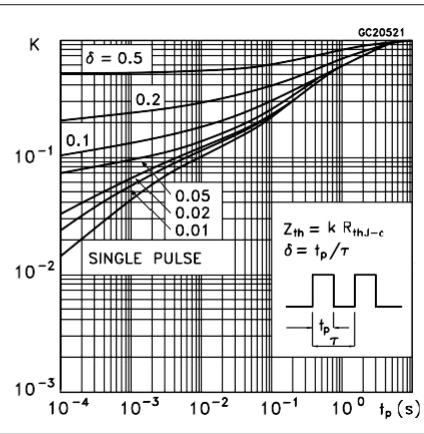


Figure 5. Output characteristics

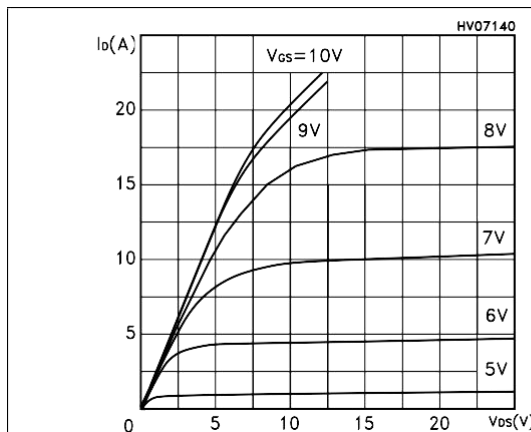


Figure 6. Transfer characteristics

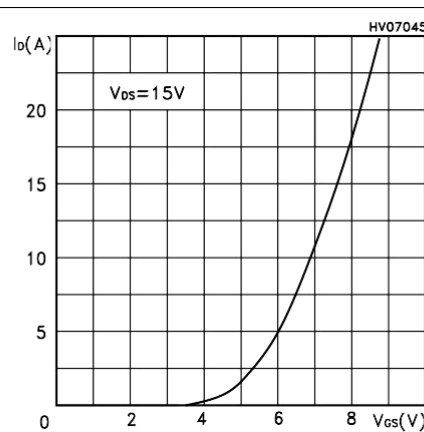


Figure 7. Transconductance

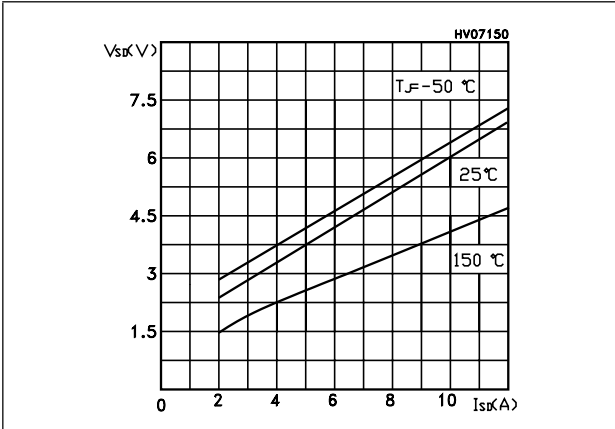


Figure 8. Static drain-source on resistance

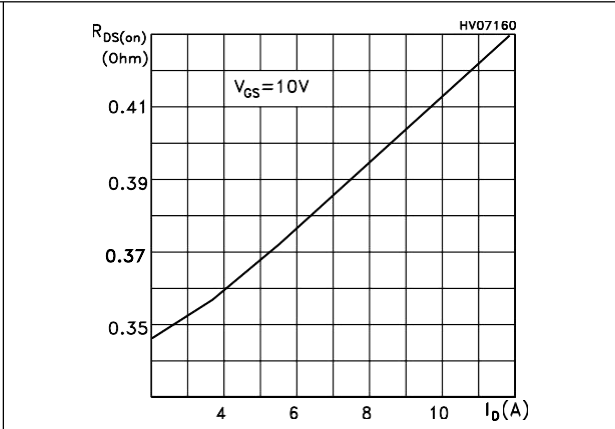


Figure 9. Gate charge vs gate-source voltage Figure 10. Capacitance variations

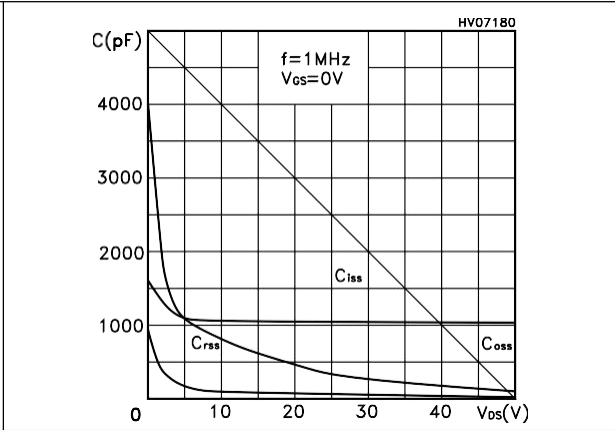
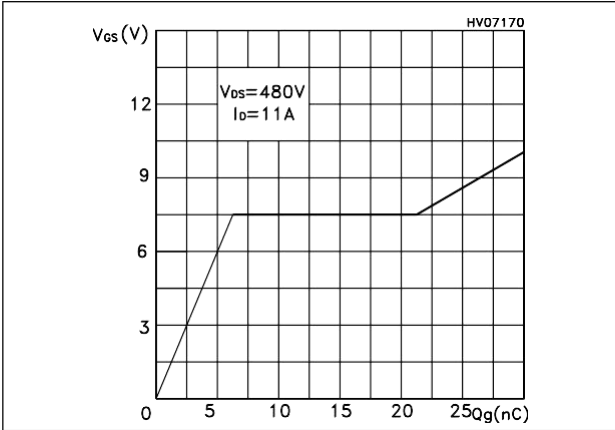


Figure 11. Normalized gate threshold voltage vs temperature

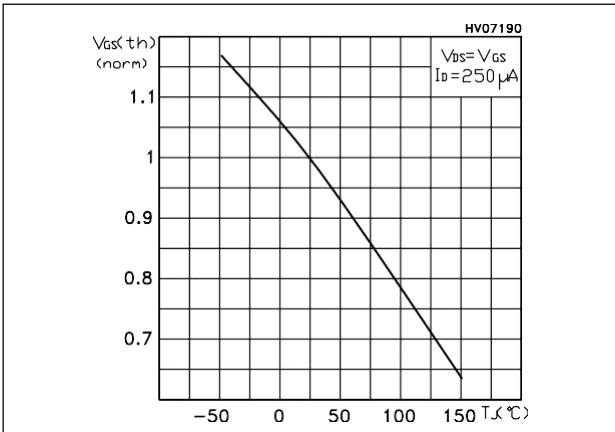


Figure 12. Normalized on resistance vs temperature

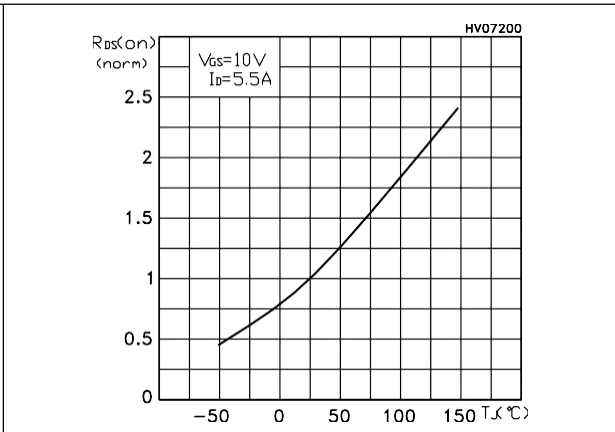
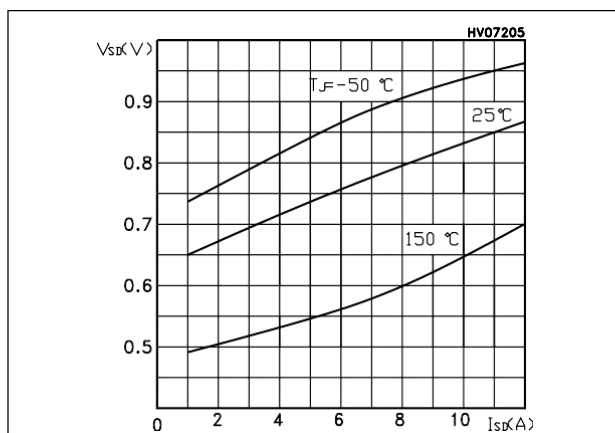


Figure 13. Source-drain diode forward characteristics



3 Test circuit

Figure 14. Switching times test circuit for resistive load

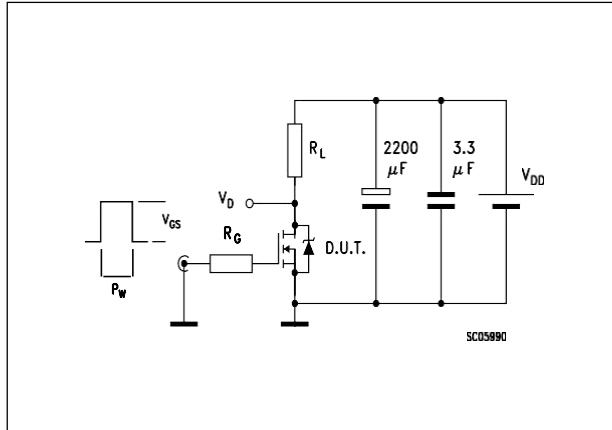


Figure 15. Gate charge test circuit

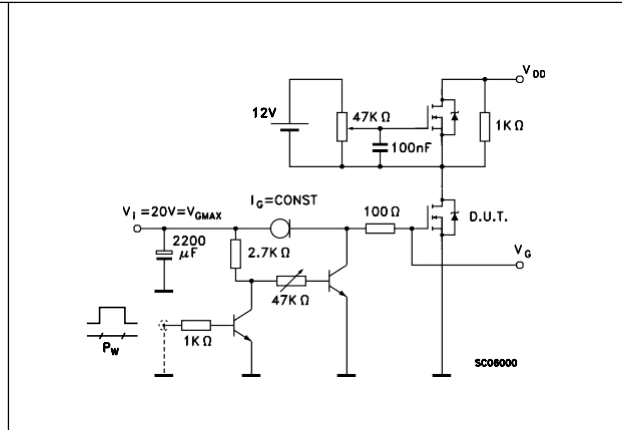


Figure 16. Test circuit for inductive load switching and diode recovery times

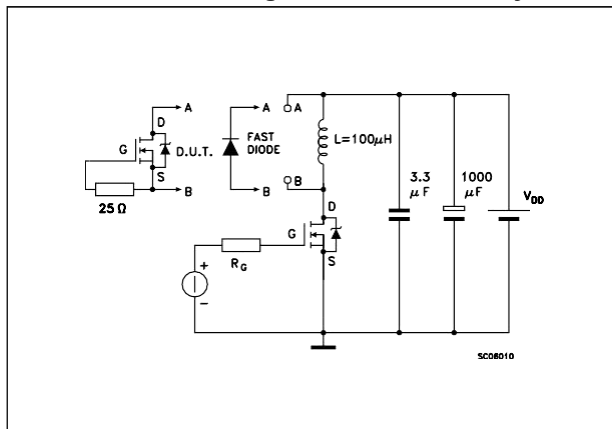


Figure 17. Unclamped Inductive load test circuit

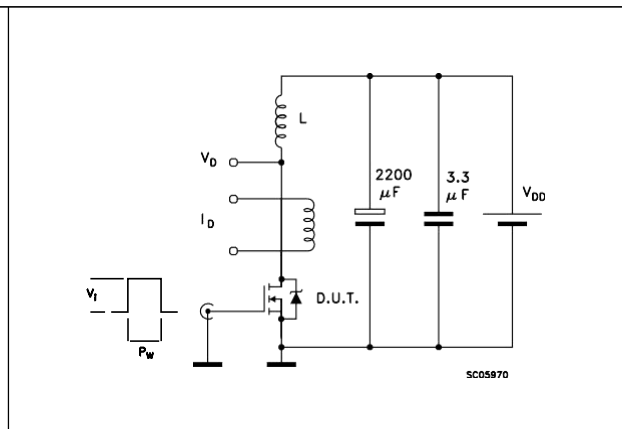


Figure 18. Unclamped inductive waveform

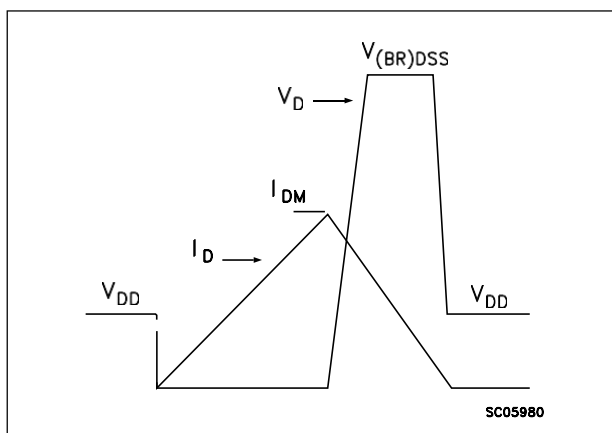
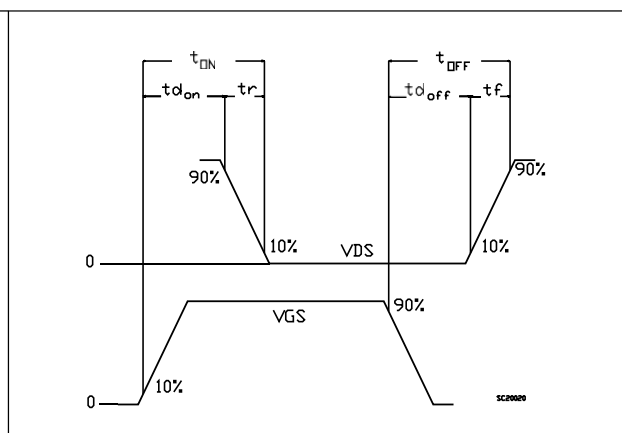


Figure 19. Switching time waveform

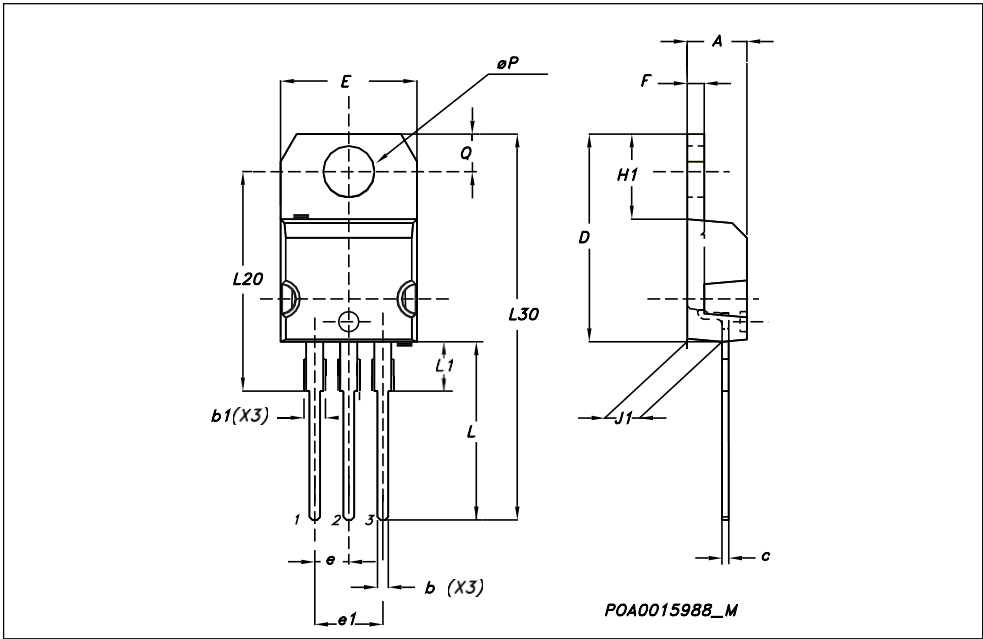


4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at : www.st.com

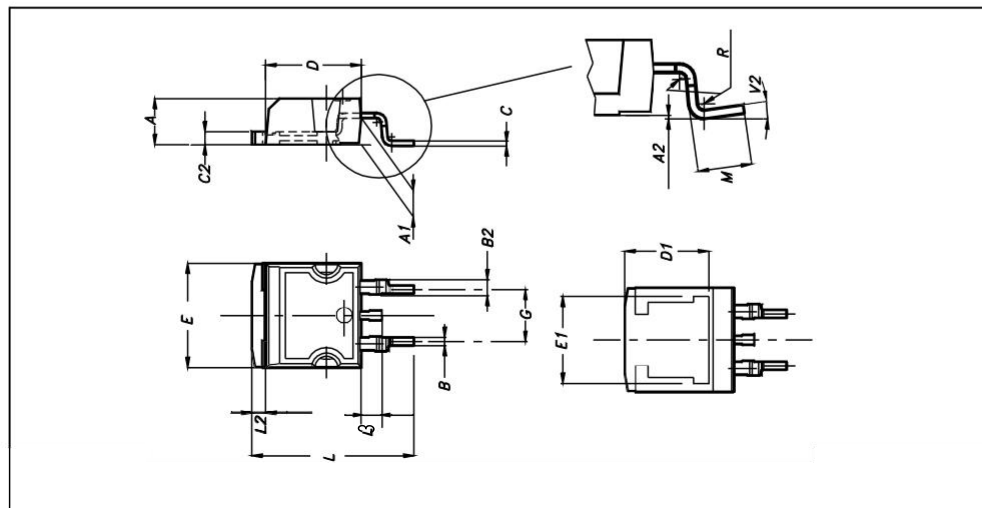
TO-220 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
øP	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



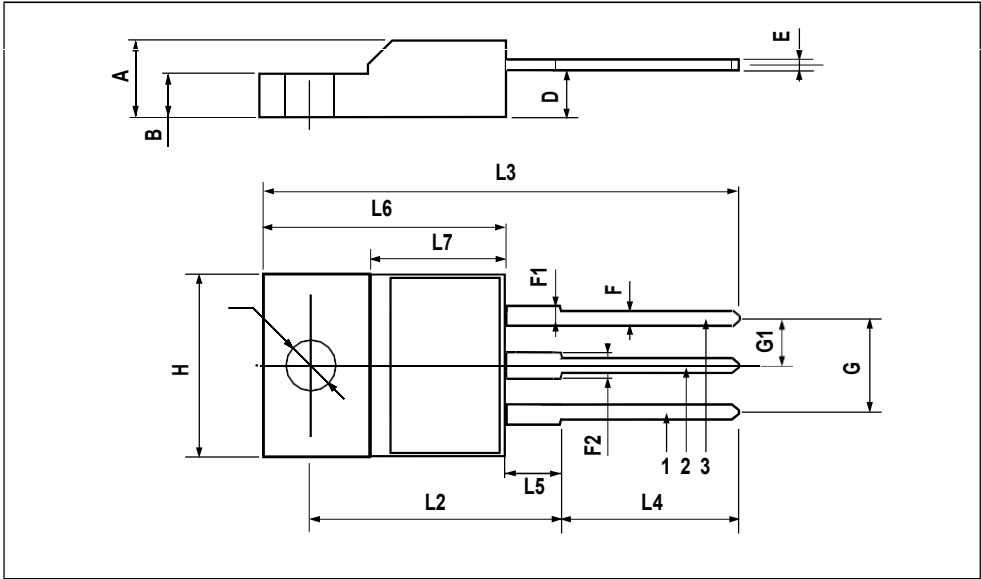
D²PAK MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
A1	2.49		2.69	0.098		0.106
A2	0.03		0.23	0.001		0.009
B	0.7		0.93	0.027		0.036
B2	1.14		1.7	0.044		0.067
C	0.45		0.6	0.017		0.023
C2	1.23		1.36	0.048		0.053
D	8.95		9.35	0.352		0.368
D1		8			0.315	
E	10		10.4	0.393		
E1		8.5			0.334	
G	4.88		5.28	0.192		0.208
L	15		15.85	0.590		0.625
L2	1.27		1.4	0.050		0.055
L3	1.4		1.75	0.055		0.068
M	2.4		3.2	0.094		0.126
R		0.4			0.015	
V2	0°		4°			



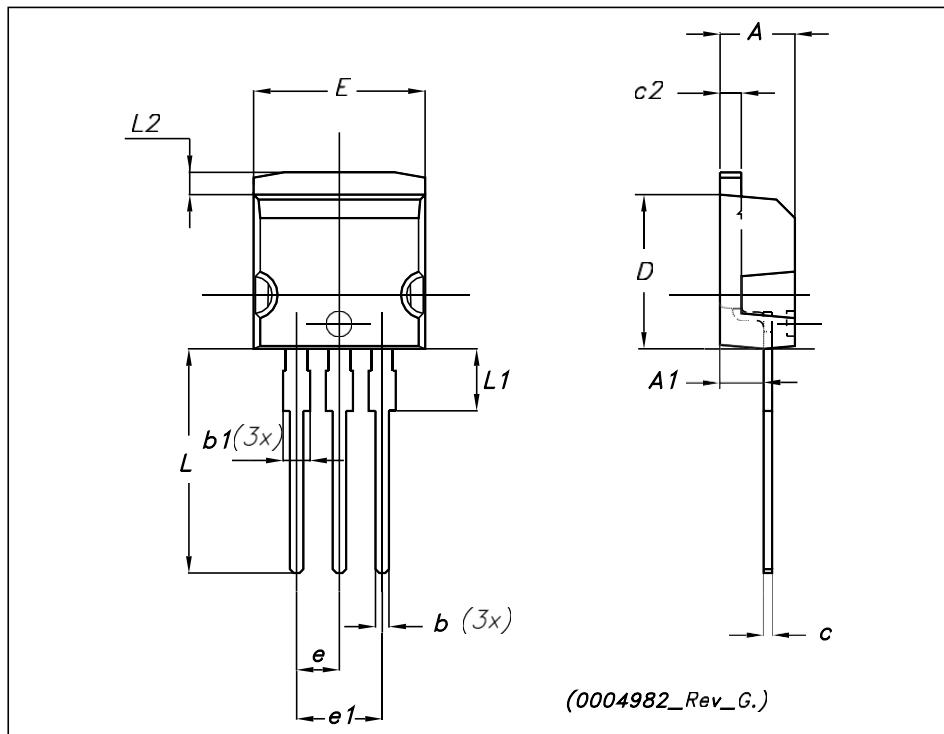
TO-220FP MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.7	0.045		0.067
F2	1.15		1.7	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	.0385		0.417
L5	2.9		3.6	0.114		0.141
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
Ø	3		3.2	0.118		0.126



TO-262 (I²PAK) MECHANICAL DATA

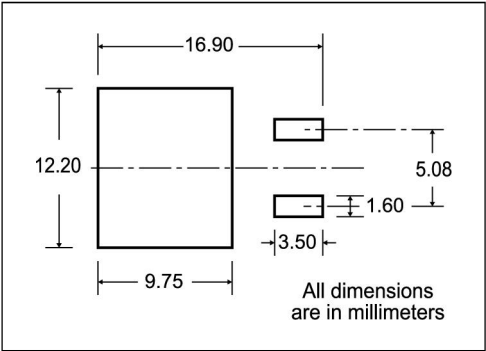
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
A1	2.40		2.72	0.094		0.107
b	0.61		0.88	0.024		0.034
b1	1.14		1.70	0.044		0.066
c	0.49		0.70	0.019		0.027
c2	1.23		1.32	0.048		0.052
D	8.95		9.35	0.352		0.368
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
E	10		10.40	0.393		0.410
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L2	1.27		1.40	0.050		0.055



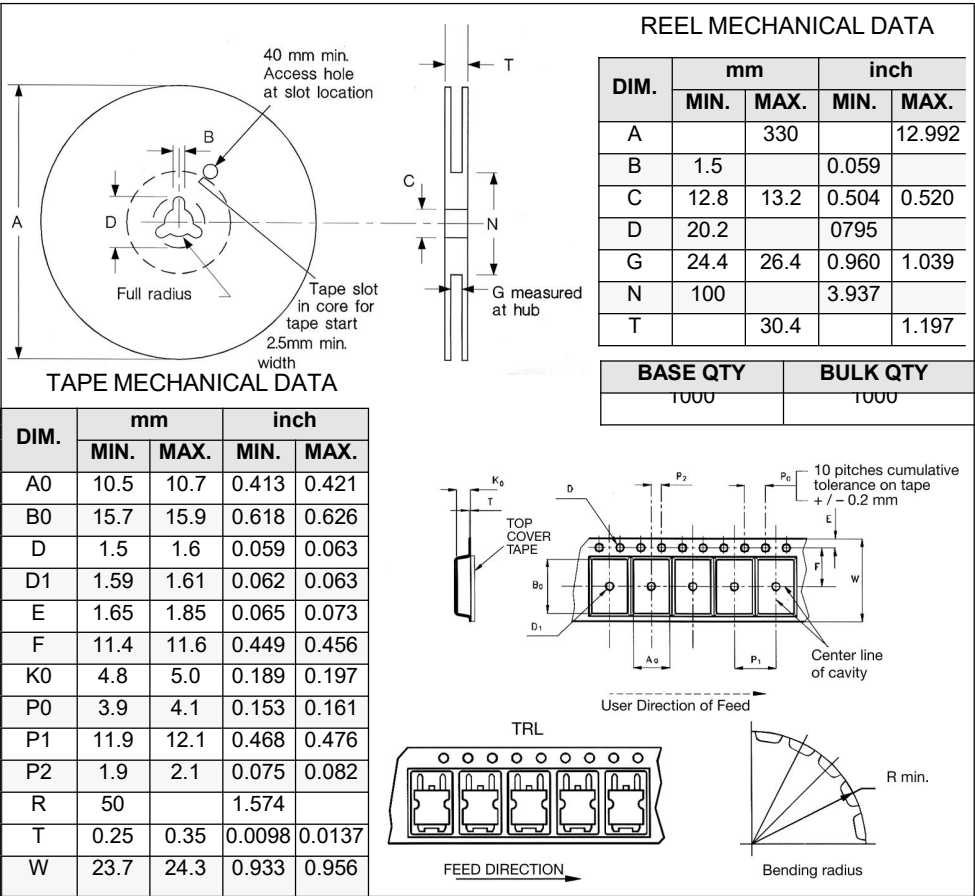
5

Packaging mechanical data

D²PAK FOOTPRINT



TAPE AND REEL SHIPMENT



* on sales type

6 Revision history

Table 8. Revision history

Date	Revision	Changes
09-Sep-2004	6	Preliminary version
08-May-2006	7	D ² PAK package inserted
22-May-2006	8	Updated values Table 5: Dynamic
26-Jul-2006	9	New template, no content change

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